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(54) **A METHOD AND DEVICE FOR CONTROL OF A MOBILITY DEVICE**

VERFAHREN UND VORRICHTUNG ZUR STEUERUNG EINER MOBILITÄTSVORRICHTUNG

PROCÉDÉ ET DISPOSITIF POUR LA COMMANDE D’UN DISPOSITIF D’AIDE AU DÉPLACEMENT

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(73) Proprietor: **Shift Robotics, Inc.**
Austin, TX 78758 (US)

(72) Inventors:
- **ZHANG, Xunjie**
Pittsburgh, PA 15213 (US)
- **KAPADIA, Anand**
Annandale, VA 22003 (US)

(74) Representative: **Forresters IP LLP**
Skygarden
Erika-Mann-Straße 11
80636 München (DE)

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Description

BACKGROUND OF THE INVENTION

[0001] The invention relates to a mobility device. More specifically, the invention relates to a control system and method of controlling a mobility device having an electric motor that is worn on the feet of a user to provide mobility assistance.

[0002] Commuters and other travelers often have to walk the final leg of their trip, regardless of whether they travelled by car, bus, train, or other means. Depending on the distance, the time needed to complete this final leg of the journey can comprise a significant amount of the total duration of the trip. While bikes or scooters can be used, they are bulky and require skill and a minimum level of fitness to operate. Powered systems, such as moving walkways, suffer from a lack of mobility. Other mobility solutions suffer the same drawbacks or lack the ability to adapt to a particular user. Therefore, it would be advantageous to develop a control system for a mobility device that does not require any special skills or user training and can adapt to the individual needs of a particular user.

[0003] WO2011092443 discloses wheeled shoes or undersoles enabling fast walking.

[0004] US2008093144 discloses a device and method for assisting a user in regaining balance.

[0005] US6059062 discloses powered roller skates.

BRIEF SUMMARY

[0006] According to embodiments of the present invention is a system and method of controlling a pair of mobility devices, wherein the mobility devices are worn on each foot of a user. A sensor in each mobility device obtains data about the gait of a user and transmits the data to a processor. The processor analyzes the gait of a user and then uses the gait data to develop motion commands for each mobility device. Each mobility device may comprise a motor, gearing, and wheels. When worn on the feet of a user, the mobility devices allow a user to walk at an increased rate of speed for a given cadence and stride length, as compared to their speed without the mobility devices. Further, the control system adapts to a user so no learning or other control inputs are required by the user.

BRIEF SUMMARY OF THE SEVERAL VIEWS OF THE DRAWINGS

[0007]

Fig. 1 depicts a mobility device with an embedded controller, according to one embodiment.

Fig. 2 is a block diagram of a control system according to one embodiment.

Fig. 3 shows the steps of the method of control, utilizing the controller depicted in Fig. 2.

DETAILED DESCRIPTION

[0008] As shown in Fig. 1, a mobility device 100, according to one embodiment, comprises a plurality of wheels 101, with at least one of the wheels 101 connected to an electric motor 102. Further shown in Fig. 1 is an onboard controller 111 and an optional remote controller 112. During typical use, a user will wear two mobility devices 100, one on each foot. The mobility device 100 enables a pedestrian to walk faster than a normal walking pace by adding torque to the wheels 101 of the mobility device 100 worn on the foot in contact with the ground. In this manner, the user experiences an effect similar to that of walking on a moving walkway. More specifically, the control system 110 of the present invention enables a user to maintain a normal walking motion by adapting the control of the motor 102 to the movements of the user. As will be discussed in greater detail, the speed at which the wheels 101 spin, through a torque applied by the motor 102, is controlled in part by an analysis of the user's gait.

[0009] Fig. 2 depicts the components of the onboard controller 111, which comprises at least one inertial measurement unit 113, a processor 114, a motor driver 115, and a wireless communication module 116. Two onboard controllers 111 are shown in Fig. 2 since each mobility device (i.e. one for each foot of the user) will house an onboard controller 111. In an alternative embodiment, the control system 110 may also include a remote controller 112, which is capable of sending commands to each of the onboard controllers 111. In this particular embodiment, both the left and right mobility devices 100 receive command speeds from the remote controller 112, which can be in the form of a hand-held controller, a computer, or a mobile phone, and actuate the mobility devices at the specified command speeds.

[0010] The control system 110 is used to collect data and analyze the gait of a user. When a pair of mobility devices 100 is worn by a user, each mobility device 100 will have a control system 110. For example, the onboard processor 114 reads gait dynamic data, which may comprise acceleration, angular rates, orientation, gyroscopic data, or quaternion data of each mobility device 100 from the inertial measurement unit 113. In one embodiment, both onboard controllers 111 send the gait dynamic data to the remote controller 112 and, in return, receive a motion command from the remote controller 112. The motion command comprises, for example, acceleration to a set speed, braking, deceleration to a set speed, and holding at a constant speed. In alternative embodiments, additional data can be included in the motion command. Upon receiving the motion command, the onboard processor 114 along with the motor driver 115 converts the motion command into a motor driving signal and drives the motor system 102, thereby affecting the speed of the wheels

101. In one embodiment, the motor driver 115 receives a speed command and drives the motor 102 at the command speed via a feedback loop control.

[0011] The flow diagram shown in Fig. 3 depicts the method of gait- based motion control, according to one embodiment, comprising the steps of receiving gait dynamic data 301, detecting the stance/swing phase 302, computing the gait trajectory vector 303, determining the user gait 304, and determining the motion command 305.

[0012] In step 301, the control system 110 receives gait dynamic data from both onboard controllers 111. The gait dynamic data includes data collected from the inertial measurement unit 113 in each mobility device 100. Next, in step 302, the control system 110 determines the status of each mobility device 100 as being 'in stance' (i.e. on the ground) or 'swing' (i.e. in the air). Then, in step 303, if the mobility device 100 is in the stance phase, a gait trajectory vector is set to zero. The gait trajectory vector may comprise an estimated foot velocity, stride length, orientation, and elevation, among other parameters. For example, acceleration in the x direction can be integrated over a period of time to determine forward velocity. Similarly, acceleration in the z direction can be used to derive elevation. By way of further example, if the elevation is positive, this could indicate that a user is climbing stairs. A negative elevation can indicate a user is travelling down a set of stairs. Acceleration in the y direction (i.e. side-to-side) can be used to derive orientation, which may be indicative of a turning motion by the user. If the mobility device 100 is in swing phase, a gait speed and trajectory vector are calculated based on the gait dynamic data. For example, in one embodiment, the acceleration data acquired from the inertial measurement units 113 is integrated to provide a velocity for each mobility device 100. The average of the velocity of both mobility devices 100 can be used to calculate the user's overall speed.

[0013] Next, at step 304, the gait speed and trajectory vectors are compared against a pre-configured gait model (or profile) which comprises a range of speeds during walking, different ranges of elevation during walking, climbing hills, or stepping on stairs. Based on the result of said comparisons, the user gait is determined. Once gait is determined, at step 305 the motion command is generated based on the determined gait. For example, if the average velocity of the two mobility devices 100 is calculated to be 1.2 m/s, then the gait is determined to be 'middle' (or any other assigned profile based on the average velocity) and requires a motion command for a wheel speed of .8 m/s. A lower average velocity may require a motion command with a lower wheel speed.

[0014] However, in optional step 306, the remote controller 112 checks if any user input has been registered. The user input can be in various forms such as pressing a button or moving the remote controller 112 in a certain trajectory. For example, the user input may press a button indicating that the user wants forward motion. Thus, the forward motion command received from the user can override the motion command provided by the controller 112 or onboard processors 111. After checking for a user input at step 306, a motion command is generated and sent by the remote controller 112 to both onboard controllers 111. However, if the user input is received from step 306, the final motion command is replaced with the user input before being sent to the onboard controllers 111.

[0015] In an alternative embodiment, each onboard controller 111 determines the gait in step 304 and generates a motion command in step 305. To prevent inconsistent commands from each onboard controller 111, each sends the motion command signal to the other for cross-validation in step 307. The motion command may include acceleration to a set speed, braking, deceleration to a set speed, and holding at a constant speed. Upon validating the motion command, the processor 1 14 along with the motor driver 115 convert the motion command into a motor driving signal and drive the motor system. Stated differently, in step 307, cross validation compares the motion commands generated by each of the two mobility devices 100. For example, the motor driver 115 will only command motor speed when both commands are similar and will brake when the speed commands are inconsistent.

[0016] While the disclosure has been described in detail and with reference to specific embodiments thereof, it will be apparent to one skilled in the art that various changes and modification can be made therein without departing from the scope of the embodiments. Thus, it is intended that the present disclosure cover the modifications and variations of this disclosure provided they come within the scope of the appended claims .

Claims

1. A method of controlling a pair of mobility devices (100), each having an electric motor (102), the method comprising:

    receiving gait data from at least one inertial measurement unit (113) in a first mobility device (100) and at least one inertial measurement unit (113) in a second mobility device (100);
    detecting a stance/ swing phase of the first mobility device (100) and the second mobility device (100) based on the gait data;
    computing a gait trajectory, wherein the gait trajectory comprises a velocity and computing the gait trajectory comprises integrating an acceleration provided by the inertial measurement unit (113) to calculate the velocity;
    determining the gait of a user based on the average velocity of the first mobility device (100) and the second mobility device (100); and
    generating a motion command using the determined gait.

2. The method of claim 1, wherein the gait data is selected from the group consisting of acceleration, angular rates, orientation, gyroscopic data, or quaternion data.

3. The method of claim 1 or 2, wherein the gait trajectory of the gait is set to zero if in a stance phase.

4. The method of any preceding claim, further comprising cross validating the motion command between the first mobility device (100) and the second mobility device (100).

5. The method of claim 4, wherein the step of cross validating the motion command comprises:
converting the motion command into a motor driving signal if the motion command of the first mobility device (100) is similar to a motion command of the second mobility device (100).

6. The method of claim 4, wherein the step of cross validating the motion command comprises:
converting the motion command into a braking signal if the motion command of the first mobility device (100) is not similar to a motion command of the second mobility device (100).

7. The method of any preceding claim, further comprising:

checking for user input from a remote controller (112), and
overriding the motion command based on the user input.

8. The method of any preceding claim, wherein the step of determining the gait of a user based on the gait trajectory comprises:
comparing the gait trajectory to a range of speeds.

9. The method of any preceding claim, wherein the gait trajectory further comprises at least one of a parameter selected from the group consisting of stride length, orientation, and elevation.

10. A computer program or computer-readable medium comprising instructions which, when executed by a computer, cause the computer to carry out the method of any preceding claim.

11. A control
system for controlling a pair of mobility devices (100), each having an electric motor (102), wherein the apparatus is configured to:

receive gait data from at least one inertial measurement unit (113) in a first mobility device (100) and at least one inertial measurement unit (113) in a second mobility device (100);
detect a stance/ swing phase of the first mobility device (100) and the second mobility device (100) based on the gait data;
compute a gait trajectory, wherein the gait trajectory comprises a velocity and computing the gait trajectory comprises integrating an acceleration provided by the inertial measurement unit (113) to calculate the velocity;
determine the gait of a user based on the average velocity of the first mobility device (100) and the second mobility device (100); and
generate a motion command using the determined gait.

12. The control system of claim 11, further comprising the first and/or second mobility devices (100).

13. The control system of claim 11 or 12, further configured to perform the method of any of claims 2-9.

Patentansprüche

1. Verfahren zum Steuern eines Paars von Mobilitätsvorrichtungen (100), wobei jede von ihnen einen Elektromotor (102) aufweist, das Verfahren umfassend:

Empfangen von Gangdaten von mindestens einer inertialen Messeinheit (113) in einer ersten Mobilitätsvorrichtung (100) und mindestens einer inertialen Messeinheit (113) in einer zweiten Mobilitätsvorrichtung (100);
Erkennen einer Stand-/Schwungphase der ersten Mobilitätsvorrichtung (100) und der zweiten Mobilitätsvorrichtung (100) basierend auf den Gangdaten;
Berechnen einer Gangtrajektorie, wobei die Gangtrajektorie eine Geschwindigkeit umfasst und Berechnen der Gangtrajektorie ein Integrieren einer Beschleunigung, die durch die inertiale Messeinheit (113) bereitgestellt wird, umfasst, um die Geschwindigkeit zu kalkulieren;
Bestimmen des Gangs eines Benutzers basierend auf der Durchschnittsgeschwindigkeit der ersten Mobilitätsvorrichtung (100) und der zweiten Mobilitätsvorrichtung (100); und
Erzeugen eines Bewegungsbefehls unter Verwendung des bestimmten Gangs.

2. Verfahren nach Anspruch 1, wobei die Gangdaten aus der Gruppe ausgewählt sind, bestehend aus Beschleunigung, Drehraten, Ausrichtung, Kreiseldaten oder Quaternionendaten.

3. Verfahren nach Anspruch 1 oder 2, wobei die Gangtrajektorie des Gangs in einer Standphase auf null

gesetzt wird.

4. Verfahren nach einem der vorstehenden Ansprüche, ferner umfassend Kreuzvalidieren des Bewegungsbefehls zwischen der ersten Mobilitätsvorrichtung (100) und der zweiten Mobilitätsvorrichtung (100).

5. Verfahren nach Anspruch 4, wobei der Schritt des Kreuzvalidierens des Bewegungsbefehls umfasst: Umwandeln des Bewegungsbefehls in ein Motorantriebssignal, falls der Bewegungsbefehl der ersten Mobilitätsvorrichtung (100) einem Bewegungsbefehl der zweiten Mobilitätsvorrichtung (100) ähnlich ist.

6. Verfahren nach Anspruch 4, wobei der Schritt des Kreuzvalidierens des Bewegungsbefehls umfasst: Umwandeln des Bewegungsbefehls in ein Bremssignal, falls der Bewegungsbefehl der ersten Mobilitätsvorrichtung (100) einem Bewegungsbefehl der zweiten Mobilitätsvorrichtung (100) nicht ähnlich ist.

7. Verfahren nach einem der vorstehenden Ansprüche, ferner umfassend:
Überprüfen, ob Benutzereingaben von einer Fernbedienung (112) vorliegen, und Übergehen des Bewegungsbefehls basierend auf der Benutzereingabe.

8. Verfahren nach einem der vorstehenden Ansprüche, wobei der Schritt des Bestimmens des Gangs eines Benutzers basierend auf der Gangtrajektorie umfasst:
Vergleichen der Gangtrajektorie mit verschiedenen Tempi.

9. Verfahren nach einem der vorstehenden Ansprüche, wobei die Gangtrajektorie ferner mindestens einen von einem Parameter, der aus der Gruppe ausgewählt ist, bestehend aus Schrittlänge, Ausrichtung und Höhe, umfasst.

10. Computerprogramm oder computerlesbares Medium, umfassend Anweisungen, die, wenn sie durch einen Computer ausgeführt werden, den Computer veranlassen, das Verfahren nach einem der vorstehenden Ansprüche umzusetzen.

11. Steuersystem zum Steuern eines Paars von Mobilitätsvorrichtungen (100), wobei jede von ihnen einen Elektromotor (102) aufweist, wobei die Einrichtung konfiguriert ist zum:

Empfangen von Gangdaten von mindestens einer inertialen Messeinheit (113) in einer ersten Mobilitätsvorrichtung (100) und mindestens einer inertialen Messeinheit (113) in einer zweiten Mobilitätsvorrichtung (100);
Erkennen einer Stand-/Schwungphase der ersten Mobilitätsvorrichtung (100) und der zweiten Mobilitätsvorrichtung (100) basierend auf den Gangdaten;
Berechnen einer Gangtrajektorie, wobei die Gangtrajektorie eine Geschwindigkeit umfasst und Berechnen der Gangtrajektorie das Integrieren einer Beschleunigung, die durch die inertiale Messeinheit (113) bereitgestellt wird, umfasst, um die Geschwindigkeit zu kalkulieren;
Bestimmen des Gangs eines Benutzers basierend auf der Durchschnittsgeschwindigkeit der ersten Mobilitätsvorrichtung (100) und der zweiten Mobilitätsvorrichtung (100); und
Erzeugen eines Bewegungsbefehls unter Verwendung des bestimmten Gangs.

12. Steuersystem nach Anspruch 11, ferner umfassend die erste und/oder die zweite Mobilitätsvorrichtung (100).

13. Steuersystem nach Anspruch 11 oder 12, das ferner konfiguriert ist, um das Verfahren nach einem der Ansprüche 2 bis 9 durchzuführen.

Revendications

1. Procédé de commande d'une paire de dispositifs de mobilité (100), chacun ayant un moteur électrique (102), le procédé comprenant :

la réception de données de marche à partir d'au moins une unité de mesure inertielle (113) dans un premier dispositif de mobilité (100) et d'au moins une unité de mesure inertielle (113) dans un second dispositif de mobilité (100) ;
la détection d'une phase d'appui/de balancement du premier dispositif de mobilité (100) et du second dispositif de mobilité (100) en fonction des données de marche ;
le calcul d'une trajectoire de marche, dans lequel la trajectoire de marche comprend une vitesse et le calcul de la trajectoire de marche comprend l'intégration d'une accélération fournie par l'unité de mesure inertielle (113) pour calculer la vitesse ;
la détermination de la marche d'un utilisateur en fonction de la vitesse moyenne du premier dispositif de mobilité (100) et du second dispositif de mobilité (100) ; et
la génération d'une commande de mouvement à l'aide de la marche déterminée.

2. Procédé selon la revendication 1, dans lequel les données de marche sont choisies parmi le groupe constitué de l'accélération, de taux angulaires, de l'orientation, de données gyroscopiques ou de don-

nées de quaternion.

3. Procédé selon la revendication 1 ou 2, dans lequel la trajectoire de marche de la marche est fixée à zéro si elle se trouve dans une phase d'appui.

4. Procédé selon l'une quelconque revendication précédente, comprenant en outre une validation croisée de la commande de mouvement entre le premier dispositif de mobilité (100) et le second dispositif de mobilité (100).

5. Procédé selon la revendication 4, dans lequel l'étape de validation croisée de la commande de mouvement comprend :
la conversion de la commande de mouvement en un signal de commande de moteur si la commande de mouvement du premier dispositif de mobilité (100) est similaire à une commande de mouvement du second dispositif de mobilité (100).

6. Procédé selon la revendication 4, dans lequel l'étape de validation croisée de la commande de mouvement comprend :
la conversion de la commande de mouvement en un signal de freinage si la commande de mouvement du premier dispositif de mobilité (100) n'est pas similaire à une commande de mouvement du second dispositif de mobilité (100).

7. Procédé selon l'une quelconque revendication précédente, comprenant en outre :
la vérification de l'entrée utilisateur à partir d'un dispositif de commande distant (112), et l'annulation de la commande de mouvement en fonction de l'entrée utilisateur.

8. Procédé selon l'une quelconque revendication précédente, dans lequel l'étape de détermination de la marche d'un utilisateur en fonction de la trajectoire de marche comprend :
la comparaison de la trajectoire de marche à une plage de vitesses.

9. Procédé selon l'une quelconque revendication précédente, dans lequel la trajectoire de marche comprend en outre au moins l'un paramètre choisi parmi le groupe constitué de la longueur de foulée, de l'orientation et de l'élévation.

10. Programme informatique ou support informatique lisible par ordinateur comprenant des instructions qui, lorsqu'elles sont exécutées par un ordinateur, amènent l'ordinateur à mettre en oeuvre le procédé selon l'une quelconque revendication précédente.

11. Système de commande permettant de commander une paire de dispositifs de mobilité (100), chacun ayant un moteur électrique (102), dans lequel l'appareil est configuré pour :

recevoir des données de marche à partir d'au moins une unité de mesure inertielle (113) dans un premier dispositif de mobilité (100) et d'au moins une unité de mesure inertielle (113) dans un second dispositif de mobilité (100) ;
détecter une phase d'appui/de balancement du premier dispositif de mobilité (100) et du second dispositif de mobilité (100) en fonction des données de marche ;
calculer une trajectoire de marche, dans lequel la trajectoire de marche comprend une vitesse et le calcul de la trajectoire de marche comprend l'intégration d'une accélération fournie par l'unité de mesure inertielle (113) pour calculer la vitesse ;
déterminer la marche d'un utilisateur en fonction de la vitesse moyenne du premier dispositif de mobilité (100) et du second dispositif de mobilité (100) ; et
générer une commande de mouvement à l'aide de la marche déterminée.

12. Système de commande selon la revendication 11, comprenant en outre le premier et/ou le second dispositif de mobilité (100).

13. Système de commande selon la revendication 11 ou 12, configuré en outre pour exécuter le procédé selon l'une quelconque des revendications 2-9.

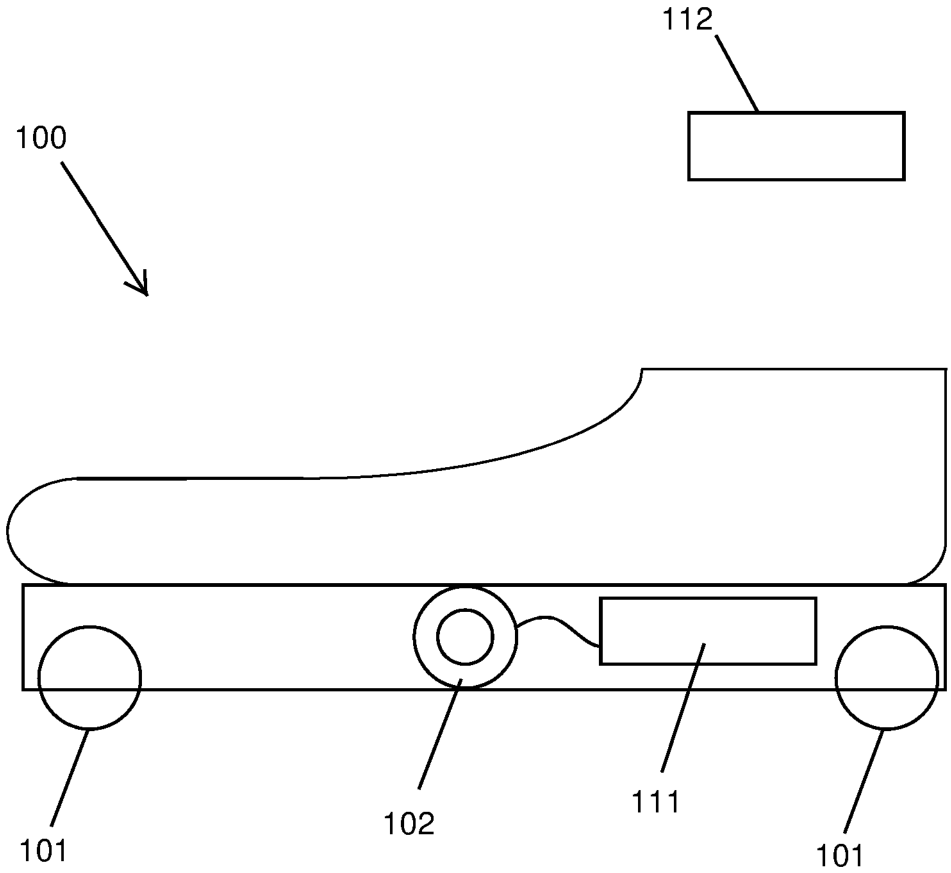

FIG. 1

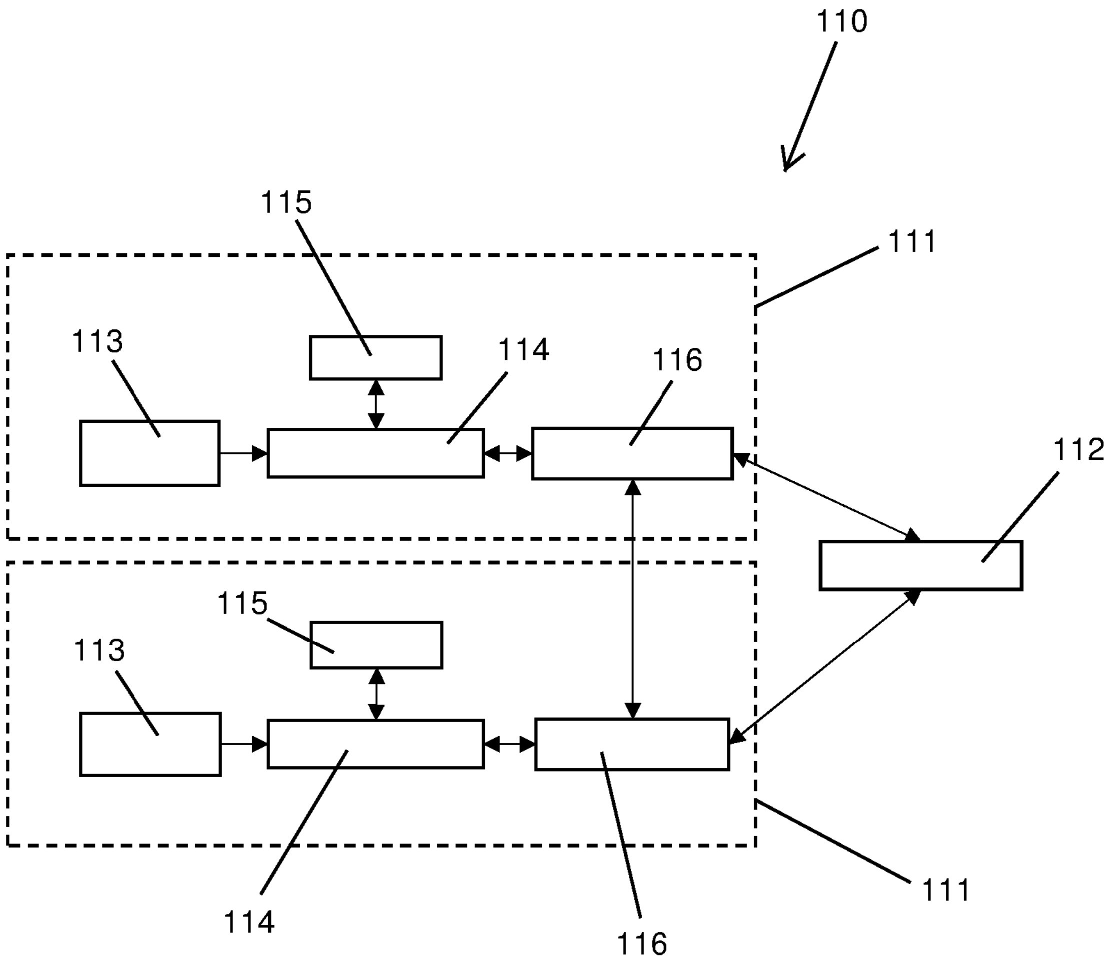

FIG. 2

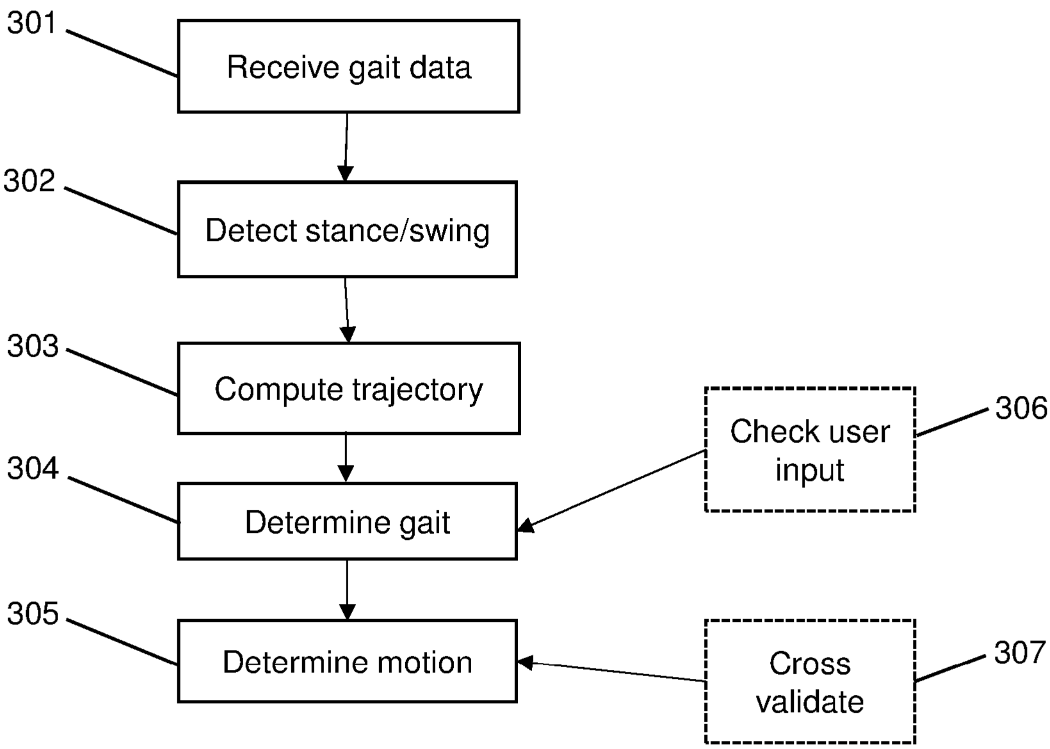
301
Receive gait data
302
Detect stance/swing
303
Compute trajectory
304
Determine gait
305
Determine motion
Check user input
306
Cross validate
307

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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- US 2008093144 A **[0004]**
- US 6059062 A **[0005]**